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Description

TUNER SHARING VIDEO RECORDER SYSTEM ARCHITECTURE

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This application is a continuation-in-part of Conflict Manager for a Video Recorder filed on February 10, 2003 as U.S. patent application 10/248,699.

COPYRIGHT STATEMENT

BACKGROUND OF INVENTION

[0003] 1. *Field of the Invention*

[0004] The present invention relates generally to systems that transfer broadcast content to volatile and/or non-volatile storage devices.

[0005] 2. *Background of the Invention*

[0006] The storage and retrieval of broadcast content gained major popularity with the advent of the video cassette recorder (VCR). A user was able to tune their television to a station that had a program that they wanted to save and they simply inserted a storage device (e.g., VHS or Beta tape), moved the tape to the appropriate location, and began capturing the broadcast. Recently, other types of equipment have developed to perform similar functionality. These types of equipment include, for instance, DVD recorders (DVD-R) and set-top boxes that transfer the content to storage devices such as hard drives and buffer memory.

[0007] Both of these types of equipment are used in a manner that is similar to the manner in which VCRs are used. Each has its own storage device (i.e., a DVD or hard drive) and each storage device is of finite space. If a user is saving a long show, multiple shows, or begins saving the show when the storage device is near a state of overflow (i.e., it is almost full), there is a chance that the program the user

is trying to save will be lost if the device becomes completely full. This is a frustrating problem for the average user, specifically when they want to save content when they are away from the home and cannot monitor how full the tape is.

[0008] Saving broadcast content in its simplest form comprises turning on a television set and pressing a record button on a VCR. More recently, VCRs, DVD recorders, and set-top boxes include interfaces, which allow users to schedule the transfer of shows at a later date or time. Using this interface, the user is able to input to the device a time and a channel and when it is the right time the device tunes to the channel and begins saving the show. This is useful, for instance, when the user is away from home and wants to see the show later.

[0009] Another modern interface allows the user to focus on a favorite show. For instance, a user may love Monday Night Football, which occurs every Monday night from 6:00 P.M to 9:00 P.M. So, the user may wish to transfer this broadcast to a storage device regardless of whether they are home or not. Using the interface, the user is able to set the system to save content for the three hours on Monday night when the football game is broadcast.

[0010] However, these schemes are inadequate because conflicts may arise in the scheduling system. Typically, a system is limited by the number of tuners it has. A one tuner system, for instance can either be used to save a show on a specific channel or watch the channel, however, the system cannot save content on one station and be used to watch another station. A two tuner system can be used to transfer and watch two different stations, but there is no current technique whereby a conflict is resolved when a user inadvertently schedules two or more shows to be saved at the same or overlapping time slots and there are not enough available tuners to perform the function.

SUMMARY OF INVENTION

[0011] The present invention is directed to a shared tuner video recorder system architecture. The present invention includes a set-top box having a storage device, such as a hard drive where broadcasts are transferred from a broadcast input source to the storage device and can later be retrieved from the storage device for viewing. The set-top box is connected to or integrated in an output device such as a television which displays a graphical user interface (GUI) and an interactive program guide (IPG). The IPG displays a list of broadcasts that are available by tuning to

different channels at different times.

[0012] The GUI allows the user to navigate through the IPG, for instance, by viewing different times and dates for broadcasts, and also allows the user to view the shows that are scheduled to be transferred to the storage device in the future, and the shows that have already been transferred to the storage device. The GUI also allows the user to utilize a video recorder by navigating the IPG and selecting broadcasts to later transfer to the storage device. The user may select one or more broadcasts, or may repeatedly transfer the same program in a series to the storage device.

[0013] In one embodiment, the user assigns a priority to each future show that is going to be transferred to the storage device. The system determines when a conflict exists, for instance, when it is scheduled to transfer two programs at the same or an overlapping time slot. In one embodiment, the system examines priorities assigned to each show and transfers only the highest priority show to the storage device. In another embodiment, the system automatically assigns a priority to a show based on a number of predetermined factors (including the length of the shows, the type of shows, and whether the shows were manually or

automatically scheduled, for instance), and solves conflicts based on the automatically assigned priority.

[0014] In another embodiment, the system examines the IPG data and searches for future broadcasts of the same scheduled shows that are in conflict. This is accomplished, for instance, by searching the titles of all of the entries in the IPG and matching a title of a later broadcast to the title of the broadcast that is currently in conflict. If the system finds one of the conflicting shows later in the IPG, it delays the transfer of that show to the storage device until its later occurrence.

[0015] In another embodiment, a series manager is used. The series manager works with the shows that are repeatedly broadcast (e.g., Cheers or General Hospital). The system may be set by the user to transfer a series to the storage device every time it occurs. Each series may be given a priority either automatically or manually. When multiple series are scheduled to be transferred to the storage device at the same or an overlapping time, the system uses the priorities to determine which series to transfer to the storage device. In another embodiment, the system determines whether a conflicting series is a first run or a repeat in the series manager. If a conflict exists between a first

run and a repeat, the first run is chosen to be transferred to the storage device.

[0016] In one embodiment, the set-top boxes are networked and configured to share tuners with each other. If a specific set-top box has no tuners available to schedule a show, it attempts to schedule the show on the tuner of another set-top box in the network.

Brief Description of Drawings

[0017] The invention will be more fully understood by reference to the following drawings, which are for illustrative purposes only:

[0018] Figure 1 is a functional block diagram of an embodiment of a set-top box.

[0019] Figure 2 is a diagram of a configuration for one of the multiple tuners associated with the video recorder.

[0020] Figure 3 shows a configuration for a single decoder.

[0021] Figure 4 is a diagram of a typical tuner arrangement for use with a live TV signal.

[0022] Figure 5 is a diagram of a typical tuner arrangement for use when transferring a signal to a storage device.

[0023] Figure 6 shows an arrangement for when a user is watching a show that has already been transferred to a storage

device.

[0024] Figure 7 shows an arrangement for when a user is watching a show on the storage device while another show is being transferred to the storage device.

[0025] Figure 8 is a flowchart showing a conflict management process according to one embodiment of the invention.

[0026] Figure 9 is a flowchart showing a conflict management process according to another embodiment of the invention.

[0027] Figure 10 is a flowchart showing a series manager according to one embodiment of the invention.

[0028] Figure 11 is a flowchart showing a series manager according to another embodiment of the invention.

[0029] Figure 12 is a flowchart showing a series manager according to another embodiment of the invention.

[0030] Figure 13 is a flowchart showing a scheduling manager according to one embodiment of the invention.

[0031] Figure 14 is a flowchart showing one example of an algorithm for returning a list of candidate shows.

[0032] Figure 15 is a flowchart showing one example of an algorithm for winnowing down a list of candidate shows to a list of candidate solutions.

[0033] Figure 16 is a flowchart showing one example of a tuner

conflict resolution algorithm.

[0034] Figure 17 is a flowchart showing an example of a manual resolution of a tuner conflict.

[0035] Figure 18 is a flowchart showing an example of an automatic resolution of a tuner conflict.

[0036] Figure 19 is a functional block diagram of a video recorder according to an embodiment of the present invention.

[0037] Figure 20 is a block diagram of a conflict resolution process according to one embodiment of the present invention.

[0038] Figure 21 is a flowchart showing a prioritization scheme according to one embodiment of the present invention.

[0039] Figure 22 is a flowchart showing how connected set-top boxes share tuners according to one embodiment of the present invention.

[0040] Figure 23 is a block diagram showing a shared tuner system architecture according to an embodiment of the present invention.

[0041] Figure 24 is a block diagram showing a shared tuner system architecture according to another embodiment of the present invention.

DETAILED DESCRIPTION

[0042] The present invention is directed to a shared tuner video

recorder system architecture. A video recorder as used herein refers to a device capable of transferring one or more broadcast signals to a storage device and retrieving the broadcast signals from the storage device. The terms video recorder, personal video recorder (PVR), and digital video recorder (DVR) are used herein interchangeably. Referring more specifically to the drawings, for illustrative purposes an embodiment of a video recorder is shown in the functional block diagram of FIG. 1.

[0043] A PVR is an internal or external component that works in conjunction with a set-top box that is used to watch television. The PVR includes some or all of a combination of software, hardware, and firmware. In one embodiment, the PVR 5 uses a disk drive 6 that is internal to a set-top box 10 where broadcasts are transferred to the storage device. The set-top box 10 connects to an output device 20, which facilitates the use of broadcast signals, such as live television signals, video on demand broadcasts, downloads of Internet content, viewing of web pages, and viewing of content transferred to the storage device. In the example of FIG. 1, set-top box 10 is shown as being external to output device 20. It should be understood by someone having ordinary skill in the art, that set-top box

10 may be internal to output device 20 as well.

[0044] A graphical user interface (GUI) 7 which includes an IPG 8 is provided and is selectively displayed on the output device 20, for instance when a user presses a specific button on a remote control 60. Alternatively, a button (not shown) on set-top box 10 may be used instead of remote control 60 anywhere a user input is needed. GUI 7 in conjunction with IPG 8 allows the user to control the PVR 5. The software or firmware that controls set-top box 10 may be installed locally or it may be downloaded from the Internet 90 as needed when configuring new set-top boxes or when updating existing ones.

[0045] Set-top box 10 is connected to output device 20 via a transmission line 30. Broadcast signals are received by the set-top box 10 via transmission line 40, which may be connected to either an antenna, a cable television outlet or a satellite connection. One or more tuner systems 45 are configured to allow the system to receive broadcast signals from multiple channels. A storage device is used, which can include a hard disk drive 6 in conjunction with a volatile memory 46, such as a Random Access Memory (RAM). The tuner system 45 works in conjunction with the storage devices 6 and 46 so that for each tuner in the

system, each can simultaneously transfer broadcast signals to the storage device 5, or display channels up to the given number of tuners on output device 20.

[0046] Set-top box 10 receives power through a line 50. Set-top box 10 receives user input entered from handheld remote control 60 over a wireless link 70, for instance by pressing a button on remote control 60. Wireless link 70 may be an infrared (IR) link, a radio frequency (RF) link, or any other suitable type of link. A bi-directional data path 80 is provided to set-top box 10, through which set-top box 10 can access the Internet 90. Transmission line 40 may provide data from a variety of input sources including cable, satellite, or electro-magnetic waves.

[0047] In one embodiment of the present invention, the PVR uses multiple tuners. Each of the tuners is normally associated with one encoder and one cache, which may be a fixed or variable size cache (for a live signal) or a fixed file in the case where the incoming signal is transferred to the storage device. Figure 2 shows various configurations for one of the multiple tuners associated with the PVR. Video stream 200 is provided to tuner 210, which passes the signal to encoder 220, which transfers the data in a cache 230. This configuration is used for analog use of a live TV

signal. Cache 230 may be any memory technique known to those skilled in the art. One embodiment implements a linked list in the cache wherein a live signal is added to the linked as individual frames and as the buffer fills the older frames at the end of the list are released from the list and re-allocated to a cache allocation system.

[0048] An alternate configuration includes a video stream 240, which is then provided to tuner 245, which is then passed to encoder 250 and then to fixed file block 260. This configuration is useful for the analog transfer of a signal. For digital channels, encoder blocks 220 and 250 are removed, since the signal has already been digitized.

[0049] Figure 3 shows a configuration for a single decoder. Cache 300 provides data to decoder 310, which outputs video signal 320. This arrangement is useful for watching live TV. Alternatively, fixed file block 330 provides data to decoder 340, which outputs a video signal 350. This embodiment is useful for playing back a show that has already been transferred to the storage device.

[0050] Each decoder shown in FIG. 3 is associated with a tuner/encoder pair. For a live TV signal, FIG. 4 shows an example of a typical arrangement, where video signal 400 is transmitted to tuner 410 then to encoder 420 and to

cache 430. After it leaves cache 430 it is decoded in block 440 and the outgoing video signal 450 is displayed on the television. It should be noted that a delay interval 460 of a given (x) number of seconds occurs between the time the signal reaches encoder 420 and is output by decoder 440. Therefore, a live TV signal is typically a signal that has been delayed by (x) seconds. If a user is watching a program and is currently transferring the program to a storage device as well, a cache, as shown in block 430 of FIG. 4 is not used. Instead, a fixed buffer 500, shown in FIG. 5 is used.

[0051] If the user is watching a show that has already been transferred to the storage device, the decoder is decoupled from the encoder (i.e., it reads from a different cache than the encoder), which continues to encode and cache the live video signal. This embodiment is shown in FIG. 6, where video signal 600 is tuned at block 605 and encoded at block 610 and stored in buffer 620. Fixed buffer 630 is used to provide data to decoder 640, which provides the output signal 650.

[0052] Finally, if a user is watching a show that resides already on the storage device while another show is currently being transferred to the storage device, two different fixed

buffers are implemented. This embodiment of the present invention is shown in FIG. 7. Video signal 700 is tuned at block 705 and encoded at block 710 and stored in a first fixed buffer 720. A second fixed buffer 730 is used to watch the previously saved show, by transmitting and decoding the data at block 740 and displaying the output video signal 750 on a television.

[0053] If there is a conflict for system resources that prevents all the desired shows from being transferred to the storage device, a prioritization system is used to determine which shows are more desirable. This system is also used to determine undesirable shows when deciding which shows to suggest to the user to delete in order to avoid conflicts. Table 1 lists factors that are taken into account by an embodiment of the present invention when comparing two shows:

[Table 1:]

Show 1	*Show 2*	*Priority*
Currently being transferred to the storage device	Other shows	Show 1 is given a higher priority.
Scheduled manually by the user to be transferred to the storage device	An episode automatically transferred to the storage device by a series manager	Show 1 is given a higher priority
An episode automatically transferred to the storage device by a series manager	An episode automatically transferred to the storage device by a series manager	The show with the highest series priority is chosen. The series priority may be set manu-

		ally. One embodiment determines this by a position in a series queue. Shows closer to the top are more desirable
Equal priority as show 2	Equal priority as show 1	The longer show is given priority.

[0054] When the system reaches a step in its logic where a conflict has been found and priority must be used to solve the conflict, the flowchart of Figure 21 shows how one embodiment of the present invention determines priority. The process begins after the existence of a conflict is discovered by the system. For instance at block 820 of Figure 8 the priorities of the conflicting shows are examined. Similarly, at block 1020 of Figure 10 the priorities of the conflicting shows, which happen to both be episodes of a series, are examined. After either of these steps occur, flow proceeds to block 2100 where the algorithm receives as input shows A and B, which are in conflict. At block 2105 it is determined if show A is actively being transferred to the storage device. If it is, then it is determined if show B is actively being transferred to the storage device at block 2110. If not, A is the higher priority and it is transferred at block 2115. If, however, B is also actively recording, then it is determined if A's running time is longer at block 2120. If so, then A is the higher priority

and it is transferred at block 2115. If, however, A"s running time is not longer, than B is the higher priority and show B is transferred at block 2125.

[0055] Returning to block 2105, if A is not actively being transferred, then it is determined at block 2130 if B is actively being transferred. If so, then show B is of a higher priority and it is transferred at block 2125. If not, it is determined at block 2135 if show A is from a series. If not, then at block 2140 it is determined if show B is from a series. If so, then show A is higher priority and it is transferred at block 2115. Otherwise, at block 2145 it is determined if show A has a longer running time than show B. If so, then show A is transferred at block 2115. Otherwise, show B is transferred at block 2125.

[0056] Returning to block 2135, if A is from a series, then it is determined at block 2150 if show B is from a series. If not, then show A is a series and show B is not, so show B is a higher priority and it is transferred at block 2125. Otherwise shows A and B are series, so at block 2155 it is determined if show A is higher up in the series manager list. Note that positions higher in the list mean a higher priority. If this is the case, than show A is transferred at block 2115. Otherwise show B is transferred at block

2125.

[0057] An embodiment of the present invention is configured to process conflicts in an optimal manner. FIG. 8 is a flowchart giving an example of how one embodiment processes conflicts. At block 800 a user schedules shows that they want the PVR to later transfer to the storage device. At block 810 it is determined if there is a conflict. If there is no conflict, the PVR transfers the shows at block 815, and block 800 repeats. If a conflict arises at block 810 (i.e., there are two programs that are scheduled to be transferred to the storage device, at least partly at the same time) a conflict resolution process begins. At block 820, the conflicting programs have their priorities examined and at block 830, the program with the highest priority is transferred to the storage device. Again, the priorities may have been explicitly set by the user or the system may automatically prioritize them as shown in Table 1.

[0058] Another embodiment of the present invention resolves conflicts in the manner illustrated by FIG. 9. At block 900, a user schedules shows to be transferred to a storage device. At block 910 it is determined if there is a conflict. If there is no conflict, the system transfers the shows to the

storage device at block 915, and block 900 repeats. If a conflict arises at block 910 (i.e., there are two programs that are scheduled to be transferred to the storage device, at least partly at the same time) a conflict resolution process begins.

[0059] At block 920, the conflicting programs have their priorities examined. At block 930, the IPG is searched for a future broadcast of the highest and lowest priority conflicting program. At block 940 it is determined if the lowest priority program was found later in the IPG. If so, then at block 950, the highest priority conflicting program is transferred to the storage device first and the lowest priority conflicting program is transferred later. If, however, at block 940 the lowest priority program was not found later, it is determined if the highest priority program was found later at block 960. If so, then at block 970, the lowest priority conflicting program is transferred to the storage device first and the highest priority conflicting program is transferred later. If, however, block 960 is false (i.e., neither program is found later, then at block 980 the highest priority conflicting program is transferred to the storage device and the lowest priority conflicting program is not transferred.

[0060] It should be noted with regard to the above scheme, that if only a portion of the two programs conflicts, then the steps taken in FIG. 9 may be applied only to the overlapping portions. This also applies to time slots that might be extended by the user at the beginning and ends of a show and also to an automatic extension (slop time) process that a PVR/DVR system might employ. For instance, a user might extend a recording for five minutes before and after a show. In that case, the extended time alone might cause a conflict and that extended time might be handled separately from the actual show to resolve the conflict. Similarly, a slop time or automatic extension might be enabled which might give rise to a conflict for only a few minutes before or after a show. In this case the slop time might be handled to resolve a conflict. Alternatively, a program may be given such a high priority that it will always be transferred to the storage device regardless of conflicts in the schedule. One embodiment locates later broadcasts, for instance, by examining the title of the currently conflicting show and performing a title search of future cells in the IPG. If a match in title is found, then the show exists later in the broadcast schedule.

[0061] With regard to Figure 9, the steps shown in this flowchart

describe an algorithm having an outer and an inner loop, wherein the outer loop finds conflicts and a the inner loop searches for later broadcasts to solve the conflict. In another embodiment of the present invention, only a single loop is used. In this embodiment when a conflict is found, one show is transferred to the storage device while the other is not. The non-transferred show is saved in a list or queue and later is transferred if possible.

[0062] Figure 20 shows how this process works. Guide data 2010, which contains the information needed to determine what shows are broadcast at certain times, is transferred to the set-top in portions over time. For instance, one day of guide data may be downloaded at a time as first portion 2040. A loop 2020 walks through the guide looking for show A 2000, which has been scheduled. It is assumed for the purposes of Figure 20, that show B 2030 has previously been scheduled and that show B has a higher priority than show A. In this example, show A 2000 is not transferred and show B 2030 is transferred.

[0063] Unlike Figure 9, where a solution is sought immediately via an inner loop, this embodiment places show A in a queue 2060. As a second portion 2070 of guide data 2010 is downloaded, for instance the next day, the system

continues walking through the guide data 2010 using loop 2020. Eventually, the system matches an entry 2080 in queue 2060 with a repeated airing of show A 2050. At this point the system is able to transfer repeated show A 2050 and the conflict is solved, since original show A 2000 is transferred and show B 2030 was also transferred. From a user perspective this is satisfactory, since they have stored both broadcasts and if the user did not immediately try to watch original show A, the whole process occurred transparently to the user.

[0064] In another embodiment, a series manager allows a user to set the PVR to transfer a broadcast series to the storage device every time it occurs in the IPG. A series is a collection of shows which the user has requested to automatically be transferred to the storage device. The request may be made, for instance, from user input made by pressing an appropriate button on an input device, such as remote control 60. Each series may be given a priority. When multiple series are scheduled to be transferred at the same time, the PVR uses the priorities to determine which series to transfer to the storage device. In another embodiment, the PVR determines whether a conflicting series is a first run or a repeat in the series manager. If a

conflict exists between a first run and a repeat, the first run is chosen to be transferred to the storage device.

[0065] FIG. 10 is a flowchart that shows how one embodiment of the series manager operates. At block 1000 one or more series are scheduled to be transferred to a storage device. At block 1010, it is determined if there is a conflict, for instance if two series are scheduled to be transferred to the storage device at overlapping times. If there is no conflict, the system proceeds normally by transferring the series to the storage device at block 1015. Then block 1000 repeats. If a conflict arises at block 1010 a conflict resolution process begins. At block 1020, the conflicting series have their priorities examined and at block 1030, the series with the highest priority is transferred to the storage device.

[0066] Another embodiment of the series manager is illustrated by FIG. 11. At block 1100 one or more series are scheduled to be transferred to a storage device. At block 1110, it is determined if there is a conflict. If there is no conflict, the system transfers the series to the storage device at block 1115 and block 1110 repeats. If a conflict arises at block 1110 (i.e., there are two series that are scheduled to be transferred to the storage device, at least partly at the

same time) a conflict resolution process begins.

[0067] At block 1120, the conflicting series have their priorities examined. At block 1130, the IPG is searched for a future broadcast of the highest and lowest priority episodes in the conflicting series. At block 1140 it is determined if the lowest priority series was found later in the IPG. If so, then at block 1150, the highest priority conflicting series is transferred to the storage device first and the lowest priority conflicting series is transferred later to the storage device. If, however, at block 1140 the lowest priority series was not found later, it is determined if the highest priority series was found later at block 1160. If so, then at block 1170, the lowest priority conflicting series is transferred to the storage device first and the highest priority conflicting series is transferred to the storage device later. If, however, block 1160 is false (i.e., neither series is found later, then at block 1180 the highest priority conflicting series is transferred to the storage device and the lowest priority conflicting series is not transferred to the storage device.

[0068] Another embodiment of the series manager is illustrated by FIG. 12. At block 1200 a user schedules one or more series to automatically be transferred to a storage device.

At block 1210 it is determined if there is a conflict. If there is no conflict, the system proceeds normally by transferring the series at block 1215, and block 1200 repeats. If a conflict arises at block 1210 (i.e., there are two series that are scheduled to be transferred to the storage device, at least partly at the same time) a conflict resolution process begins.

[0069] At block 1220, the IPG is searched to determine if the first conflicting series is a first run. If the first conflicting series is a first run, then at block 1230 it is determined if the second conflicting series is a first run. If the second conflicting series is not a first run, meaning it is a repeat showing of a past episode in the series, then the first conflicting series is transferred to the storage device at block 1240. If, however, the second conflicting series was a first run at block 1230, then both conflicting series have their priorities examined at block 1250 and at block 1260 it is determined if the first conflicting series has a higher priority than the second conflicting series. If block 1260 is true, then the flow proceeds to block 1240 where the first conflicting series is transferred to the storage device. Otherwise, if block 1260 is false, then the second conflicting series is transferred at block 1270, since it had a

higher priority.

[0070] Returning to block 1220, if the first conflicting series was not a first run, then at block 1280 it is determined if the second conflicting series is a first run. If so, flow proceeds to block 1270 where the second conflicting series is transferred to the storage device. Otherwise, block 1280 is false, so flow proceeds to block 1250 and the priority examination process continues.

[0071] One embodiment of the scheduling manager comprises a collection of algorithms for managing the scheduling of shows for use on a digital video recording system with one or more tuners and an interactive program guide (IPG). In general, the scheduling manager operates by initiating an algorithm, which checks for the existence of a conflict which asks the PVR to transfer more shows to a storage device at a particular time than the PVR is able to transfer. If a conflict is found, another algorithm is initiated, which generates all of the possible solutions to the conflict. Then, the conflict is resolved either automatically or manually.

[0072] FIG. 13 shows the general operation of the scheduling manager according to one embodiment of the present invention. At block 1300, it is determined if a new show has

been scheduled to be transferred to the storage device. For instance, a user might request that a particular show in the IPG be added to a schedule queue. The schedule queue comprises a list of entries containing metadata about shows to be transferred to the storage device in the future. In one embodiment, shows closer to the bottom of this queue are further in the future.

[0073] Block 1300 repeats until it is found that the user has requested a particular show in the IPG to be added to a schedule queue. When it is true, block 1310 determines if a conflict exists, for instance, no additional tuner is available. If not, the show is scheduled to be transferred to the storage device at block 1320 and block 1300 repeats. Otherwise, at block 1330 an algorithm is initiated to determine the possible solutions to the conflict. At block 1340 it is determined if an automatic resolution is needed. If so, then the conflict is automatically resolved at block 1350 and block 1300 repeats. Otherwise, the conflict is resolved manually at block 1360 (i.e., the user chooses the solution) and block 1300 repeats.

[0074] One embodiment of the invention uses algorithms to check if there is a tuner conflict with a selected show (which the user intends to schedule). The algorithms

function regardless of the number of tuners available. First a candidate list of shows is returned, which might be in conflict because they overlap in time. Then, the candidate list of shows is reduced to those cases where an actual conflict exists.

[0075] FIG. 14 is one example of an algorithm for returning a list of candidate shows. The algorithm uses the scheduling queue and a transfer queue comprising a list of shows scheduled to be saved which have already been transferred, including shows being actively transferred. When a show starts to be transferred to the storage device, it is moved from the top of the schedule queue to the top of the transfer queue. Shows closer to the bottom of the transfer queue are deleted first.

[0076] First, at block 1400 the algorithm takes as input the target show for which a conflict needs to be checked for. At block 1410 any prior candidate list is cleared. At block 1420, for each show in the transfer queue, if the show is actively being transferred to the storage device, and its timeslot overlaps the target show, it is added to the list of candidate shows. Once each show in the transfer queue is examined, then at block 1440, for each show in the schedule queue, if the show's timeslot overlaps the target

show, it is added to the list of candidate shows. At block 1470 the list of candidate shows is returned.

[0077] Once a list of candidate shows that might conflict is returned as shown in FIG. 14, an algorithm is implemented, which returns a list of shows which are in actual conflict for tuners. This algorithm is used to winnow down the list returned by the embodiment shown in FIG. 14, to exactly those shows which are in conflict for the available tuners. This embodiment is shown in FIG. 15.

[0078] First, at block 1500 the algorithm takes as input the target show for which a conflict needs to be checked for and a list of candidate shows which overlap the time slot of the target show. At block 1510, a candidate show X, whose leading edge overlaps the target show, is selected. At block 1520, N is set to the number of candidate shows whose timeslot overlaps X. At block 1530, it is determined if N >= (the number of tuners). If so, then there is a conflict, and the show X is flagged as being in conflict at block 1540. After block 1540, or if there is no conflict at block 1530, then at block 1550 it is determined if there is another candidate show X. If so, block 1510 repeats.

[0079] When all candidate shows have been selected, then at block 1560 M is set to the number of shows for which the

leading edge of the target show overlaps. At block 1570, it is determined if M >= the number of tuners. If so, all shows M are marked as being in conflict as well, at block 1580. After block 1580 or if block 1570 is false, all candidates which have been marked as being in conflict are placed in a "conflict list" and returned at block 1590.

[0080] Once tuner conflicts are identified, one embodiment of the invention is configured to generate a list of potential solutions for resolving the tuner conflict. It receives as input a target show, which the user wishes to transfer to the storage device, and a list of shows which are in conflict with the target show for tuners, this list is created for instance, as shown in FIG. 15. The algorithm outputs a list of 0, 1 or 2 solution-lists to any tuner conflicts, each solution-list contains 1 or more shows from the conflicts list.

[0081] Deleting all the shows in the solution-list will resolve all potential tuner conflicts for the target show. For the very common case of having 2 tuners, and exactly 2 shows in conflict, deleting either of the two shows to resolve the conflict. In this case a list of those two solutions is returned (show A and show B), and the remaining steps are skipped. For the situation where the number of conflicts is

greater than some arbitrary limit, it is computationally expensive to do a brute force search for conflicts. In this case, one embodiment prunes the list of candidates by keeping only one show per timeslot. The longest available show for each time slot is kept, but since these shows are used as candidates for deletion, given multiple shows of the same length, shows the user has indicated are less desirable are chosen.

[0082] Then, every possible subset list of those candidate shows is generated, starting with the shortest lists (all the 1-show lists, followed by all the 2-show lists, and so on...). Each list is a 'candidate solution'. As each candidate solution is generated, it is tested to see if it fixes the problem. This is accomplished by making a copy of the conflicts list, and removing the candidate-solution shows from the conflict list, and then checking to see if any of the remaining shows are still in conflict.

[0083] If no conflicts remain, then the solution is added to a list of saved-candidate-solutions. If at least one candidate solution of length N is generated, then longer length candidates are not generated. The list of saved-candidate solutions is sorted, putting more desirable solutions first. More desirable solutions contain more shows which are

deemed to be less desirable. The first two saved-candidate solutions (if any) are returned to the user. The rest are thrown away.

[0084] This process is described in FIG. 16. At block 1600, a target show and a list of shows which are in conflict with the target show are received. At block 1610, it is determined if the number of conflicts is greater than the number of available tuners. If not, then the number of conflicts is less than or equal to the number of tuners, so the list of solutions is returned at block 1620. Otherwise, after block 1610 the conflict list is pruned by keeping only one show per timeslot at block 1640. Then, the candidate solutions are tested and generated at block 1650. At block 1660, it is determined if any conflicts remain. If so, then at block 1665 one of the conflicts is removed and block 1650 repeats. Once no conflicts remain, the candidate solution is added to the list of saved candidate solutions at block 1670.

[0085] One embodiment of the present invention is configured to present a conflict to the user and allow them to resolve it manually. This occurs, for instance, when a user attempts to schedule a target show X for future transfer to the storage device, and there is a conflict. In this case, one em-

bodiment uses the following method to resolve the conflict:

[0086] ·A list of candidate solutions to the conflict is generated; and

[0087] ·The user is presented with choices for resolving the conflict.

[0088] In the most common case, in which there are exactly 2 solutions, each of which involves deleting only 1 scheduled show, the user is presented with three choices:

[0089] ·Cancel the show in solution A from the schedule;

[0090] ·Cancel the show in solution B from the schedule; or

[0091] ·Do not transfer the target show X to the storage device.

[0092] Otherwise, the user is presented with only 2 choices:

[0093] ·Cancel all the scheduled shows in solution A from the schedule (however many there are); or

[0094] ·Do not transfer the target show to the storage device.

[0095] FIG. 17 shows how manual deletion is implemented by one embodiment of the present invention. At block 1700 a user schedules shows to be transferred to a storage device. At block 1710 it is determined if there is a conflict in a show the user has scheduled to be transferred to the

storage device. If not, the show is transferred at block 1715 and block 1700 repeats. When a conflict arises, a list of candidate solutions is generated at block 1710.

[0096] At block 1720, it is determined if there are exactly two solutions, each of which can be resolved by deleting only one show. If so, then at block 1730, it is determined if the user wants to cancel the show in solution A from the schedule. If so, the conflict is solved at block 1740. Otherwise, after block 1730 it is determined if the user wants to cancel the show in solution B from the schedule. If so, it is canceled at block 1750 and the conflict is solved at block 1740. Otherwise, the target show X is not transferred to the storage device at block 1760 and the conflict is solved at block 1740.

[0097] If however, at block 1720, there are not exactly two solutions, then at block 1770, it is determined if the user wants to cancel all the scheduled shows in solution A from the schedule. If so, the conflict is solved at block 1740. Otherwise block 1760 repeats, where the target show is not transferred to the storage device and the conflict is solved.

[0098] When the series scheduler attempts to automatically schedule a target show X for future transfer to the storage

device, and a conflict arises, one embodiment of the present invention is configured to resolve conflicts automatically without user intervention. In this scenario, a list of solutions to the conflict is generated and a course of action is chosen based on the available list of solutions. If all the shows in the first solution are lower in priority than the target show the first solution is bumped by canceling all its shows. Otherwise, if there is a second solution and all its shows are lower in priority than the target show, the second solution has all of its shows canceled. Otherwise, there are no desirable solutions to the conflict, so the target show is not transferred to the storage device, and it is marked as bumped.

[0099] Figure 18 shows how this embodiment of the present invention operates. At block 1800 the user or the series manager schedules shows to be transferred to the recording device. At block 1805 it is determined if there is a conflict in a show the user or a series manager has scheduled to be transferred to the storage device. If not, the shows are transferred at block 1810 and block 1800 repeats. When a conflict arises, it is determined at block 1815 if a manual resolution is going to be used. If so, the conflict is manually resolved at block 1820. Otherwise, the

conflict is to be handled by an automatic resolution process at block 1830 and to that end a list of candidate solutions is generated at block 1840.

[0100] From the candidate list of solutions, it is determined if all the shows in the first solution are lower in priority than the target show at block 1850. If so, the first solution is bumped by canceling all its shows at block 1860. Otherwise, it is determined if there is a second solution at block 1870. If so, it is determined if all its shows are lower in priority than the target show at block 1880. If so, the second solution has all of its shows canceled at block 1890. If, however, there is not a second solution, or if block 1880 is false, there are no desirable solutions to the conflict, so the target show is not transferred to the storage device, and it is marked as bumped at block 1895.

[0101] FIG. 19 is a functional block diagram that illustrates the components of an embodiment of the present invention. Note that FIG. 19 is intended to be a conceptual diagram and does not necessarily reflect the exact physical construction and interconnections of these components. Set-top box 10 includes processing and control circuitry 1900, which controls the overall operation of the system. Coupled to the processing and control circuitry 1900 are

one or more TV tuners 1910, a storage device 1920, a communication device 1930, and a remote interface 1940.

[0102] Tuners 1910 receive the television signals on transmission line 1960, which may originate from an antenna or a cable television outlet. Processing and control circuitry 1900 provides audio and video output to output device 190 via a line 1970. Remote interface 1940 receives signals from remote control 60 via wireless connection 70. Communication device 1930 is used to transfer data between set-top box 10 and one or more remote processing systems, such as a web server 1980, via a data path 1990.

[0103] Processing and control circuitry 1900 may include one or more of devices such as general-purpose microprocessors, digital signal processors, application specific integrated circuits, various types of signal conditioning circuitry, including analog-to-digital converters, digital-to-analog converters, input/output buffers, etc. Storage device 1920 may include one or more physical memory devices, which may include volatile storage devices, non-volatile storage devices, or both. For example, storage device 1920 may include both random access memory, read-only memory, hard disk drives, various forms of programmable and/or erasable ROM, flash memory, or

any combination of these devices.

[0104] Communication device 1930 may be a conventional telephone (POTS) modem, an Integrated Services Digital Network (ISDN) adapter, a Digital Subscriber Line (xDSL) adapter, a cable television modem, or any other suitable data communication device. Logic 1995 typically couples to memory 1920. Logic 1995 may be used when PVR 5 has been given conflicting instructions to transfer two or more programs to storage device 1920 simultaneously. One or more of the algorithms and processes described herein to manually and/or automatically resolve conflicts are stored in logic portion 1995. Logic portion 1995 may, in part, also be referred to as a conflict manager. Logic portion 1995 may control the buffering portion 1999 by varying the size and amount of the buffered input signal, which is reproduced as the delayed live television signal. Logic portion 1995 is associated with the PVR 5 and is shown conceptually as a separate block. However, this is conceptual only. Logic portion 1995 and PVR 5 may be integrated together and logic portion 1995 may also reside, in whole or in part, in storage device 920 or buffering portion 1999.

[0105] In one embodiment of the present invention, scheduling

conflicts are resolved by a first set-top box finding and using an available tuner from another set-top box that is connected to the first set-top box. Figure 22 is a flowchart showing how connected set-top boxes share tuners. At block 2200 a user schedules shows that they want the PVR to later transfer to the storage device. At block 2210 it is determined if there is a conflict. If there is no conflict, the show is scheduled at block 2220.

[0106] If a conflict arises at block 2210, then at block 2230, the set-top box searches for another set-top box with an available tuner. At block 2240, it is determined if there is another connected set-top box with an available tuner. If so, then at block 2220, the show is scheduled. Otherwise, at block 2250 the show is not scheduled.

[0107] Figure 23 is a diagram showing a system architecture utilizing shared tuners according to an embodiment of the present invention. Figure 23 is used, for instance, when implementing the steps shown in connection with Figure 22. Figure 23 includes set-top boxes 2300, 2301, 2302, 2303, 2304, 2305. Each set-top box 2300-2305 is shown as having one or more tuners. Each set-top box may be configured to have any number of tuners in other embodiments of the present invention. Set-top box 2300 has

three tuners, 2309, 2310 and 2311. Set-top box 2301 has tuners 2312 and 2313. Set-top box 2302 has one tuner 2315. Set-top box 2303 has tuners 2316 and 2317. Set-top box 2304 has tuners 2318 and 2319. Set-top box 2305 has four tuners, 2320, 2321, 2322, and 2323.

[0108] Tuners 2320-2323 of set-top box 2305 are shown as being not available. If a user of set-top box 2305 wants to use another tuner, typically, set-top box 2305 will be unable to do so or it must resolve a scheduling conflict by not scheduling a show or not displaying a show on an output device. With a shared tuner architecture, however, set-top box 2305 can query the network to see if another tuner will not be in use and can be currently scheduled by set-top box 2305.

[0109] In operation set-top box 2305 might query the network in a number of ways, but it is assumed for the purposes of this example that set-top box 2305 first queries set-top box 2304. Set-top box 2304 is shown as having its tuners 2318 and 2319 as unavailable. In this case set-top box will next query set-top box 2303. Set-top box 2303 is shown as having tuner 2316 as unavailable and tuner 2317 as available. For instance, a user of set-top box 2303 might be watching television using tuner 2316, but

no other operation is being performed using set-top box 2303.

[0110] In this case set-top box 2305 asks set-top box 2303 for use of tuner 2317 and its permission is granted. When set-top box 2305 has completed use of tuner 2317 it is released back to set-top box 2303 for its use later if needed. It should be noted that each set-top box 2300-2305 may have any number of tuners from 1 through N. Moreover, a shared tuner architecture may have any number of set-top boxes interconnected from 2 through N. The set-top boxes (2-N) may all be interconnected within a single household, or a network may be set up comprising many boxes at different interconnected locations.

[0111] Figure 24 shows a shared tuner architecture according to another embodiment of the present invention. In the architecture of Figure 24 there are four set-top boxes 2400, 2401, 2402, and 2403. Display devices 2410, 2411, 2412, and 2413 may be, for instance, television sets connected to and configured to display output from set-top boxes 2400-2403. A broadcast signal 2420 comprised of a plurality of component signals 2422 provides input to each set-top box 2400-2403 via an interconnected network

2430. Each of the component signals 2422 may be, for instance, the signal needed to receive a specific television channel, such as CNN, ABC, FOX, etc or data needed to display a program guide. Each set-top box 2400-2403 is configured to receive broadcast signal 2420 and extract the component signals 2422 as needed.

[0112] Interconnected network 2430 comprises bi-directional connections to each set-top box 2400-2403. In the example of Fig. 24, an interconnect 2432 is used wherein each set-top box 2400-2403 has access to every other set-top box 2400-2403 via a direct bi-directional connection 2435, 2436, 2437, and 2438 to interconnect 2432. Each set-top box 2400-2403 has one or more tuners, 2440, 2441, 2442, and 2443, one or more encoders 2450, 2451, 2452, and 2453, a cache 2460, 2461, 2462, and 2463, a storage device 2470, 2471, 2472, and 2473, and one or more decoders 2480, 2481, 2482, and 2483. Fig. 24 is for purposes of example only. One skilled in the art will note that there may be other additional components in set-top boxes 2400-2403 that are omitted for the purpose of clarity.

[0113] In operation, broadcast signal 2422 is provided to the network 2430 via a service provider. The signal might be

routed to set-top box 2400, for instance. The signal is received at tuner 2440 and decoded at 2450. Depending on the operation needed, the signal is then transferred to cache 2460, storage device 2470, or both. The signal is also transferred from cache 2460 or storage device 2470 through decoder 2480 and to display device 2410 as needed.

[0114] If any set-top box 2400-2403 needs to use a tuner and it is not available, it may attempt to use the tuner of another set-top box 2400-2403. For instance, if all of the one or more of the tuners represented in block 2440 of set-top box 2400 are unavailable for an operation such as displaying a channel or recording a show to storage device 2470, set-top box 2400 has the ability to query network 2430 for another available tuner. For instance, set-top box 2400 might use line 2435, interconnect 2432, and then line 2436 to ask set-top box 2401 if tuner 2441 is ready and available. If so, set-top box 2401 will give set-top box 2400 the use of tuner 2441. If tuner 2441 is not ready and available, set-top box 2400 might ask set-top box 2403 for the use of tuner 2443, via line 2435, interconnect 2432, and then line 2438.

[0115] Although the description above contains many specifici-

ties, these should not be construed as limiting the scope of the invention but as merely providing illustrations of some of the presently preferred embodiments of this invention. Thus the scope of this invention should be determined by the appended claims and their legal equivalents.